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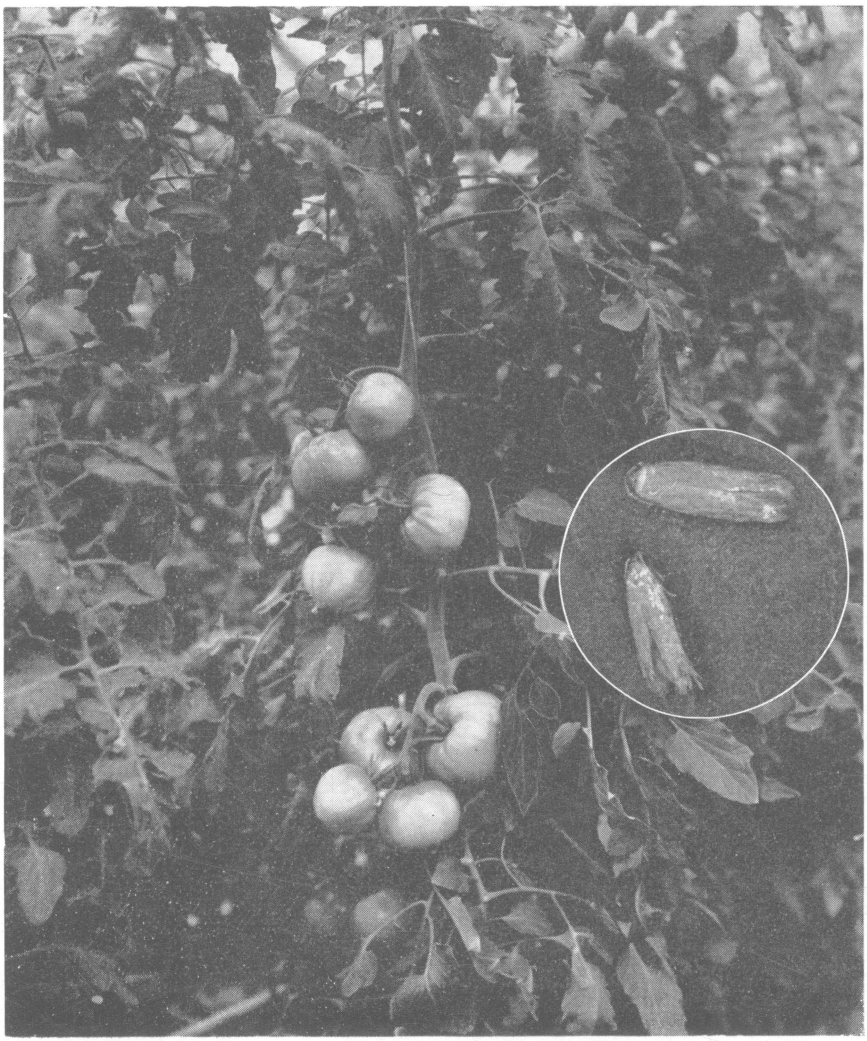
THE TOMATO PINWORM



OHIO AGRICULTURAL EXPERIMENT STATION
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SUMMARY

The tomato pinworm (*Kieferia lycopersicella* Kiel.) was first found in Ohio in 1944. Although it may feed on potato and eggplant, it is primarily a pest of tomato.

Because it does not live over winter out of doors in this latitude, in Ohio it is a pest only in greenhouses or in tomato fields located near infested greenhouses.

Larvae feed primarily as leaf miners but sometimes invade the stems and fruits of tomato. A full-grown larva is approximately one-fourth inch in length.

The life history of the insect, in which it passes through the stages of egg, larva, pupa, and adult, may be completed in four weeks during periods of hot weather. At lower temperatures, however, the life cycle is lengthened.

In control experiments, sprays or dusts containing cryolite or DDT proved effective, and a high percentage of the moths were killed by nicotine fumigation.

Commercially a 3 percent purified or aerosol grade DDT dust applied at the rate of 25 pounds per acre has proved adequate.

As a result of effective control measures, the pinworm has apparently been eliminated from certain Ohio communities and the population over the entire area has been greatly reduced.

Cover: Tomato plants growing inside a greenhouse. The inset shows two pinworm moths greatly enlarged. The moth is gray in color, about one-fourth inch long, and is similar to the clothes moth in general appearance. The moths remain concealed amid the tomato foliage in the day-time but become more active at dusk. The eggs are deposited somewhat indiscriminately over the tomato plant but most of them occur on the underside of the leaves.

THE TOMATO PINWORM

R. B. Neiswander

INTRODUCTION

Hothouse tomatoes constitute an important agricultural crop in Ohio. Although the acreage under glass devoted to tomatoes has not been completely surveyed, it is known to exceed greatly that of any other state. It has been estimated by the best informed individuals at 360 to 500 acres. The annual gross sales in recent years have been estimated at 8 to 12 million dollars.

When the tomato pinworm, *Keiferia lycopersicella* (Busck), with its potentially destructive powers, was found to attack hothouse tomatoes in Ohio, a significant agricultural enterprise was temporarily threatened. This bulletin is presented to portray the life history and habits of the insect as it occurs in Ohio, and to show the results of control experiments as well as the results of the commercial application of the information obtained.

DISTRIBUTION

The tomato pinworm, *Kieferie lycopersicella* Kief., was first recognized as a pest of tomatoes in California by A. W. Morrill in 1923 (4). It was described as a separate species in 1928 (1). In addition to the United States it is known to occur in Mexico, Hawaii, Central and South America, and in some of the West Indian Islands (2, 3, 9).

The pinworm is primarily a pest in warm climates. In this country it causes trouble in field-grown tomatoes only in the most southern states. In Pennsylvania, Mississippi, Delaware, Missouri, and Virginia, as well as in Ohio, it has been reported as being a pest only of tomatoes growing under glass and in fields near infested greenhouses (3, 8, 9).

THE INFESTATION IN OHIO

This insect was first found in Ohio during the summer of 1944 (5). On August 8 a heavy infestation was observed in a greenhouse near Rocky River. Pinworm larvae could be found in nearly every leaflet in the old tomato vines which were being removed from the greenhouse. Seven larvae were taken from each of several tomatoes. Many young potted plants which were being prepared for the next crop were severely damaged. By late fall of that year the infested area had extended several miles west and south of Cleveland.

During 1945 (6) the infested area extended southward approximately 15 miles from Lake Erie and extended from Elyria eastward through the Schaaf Road section of Cleveland. A number of tomato

fields located near infested greenhouses were damaged by the insect. A somewhat isolated infestation appeared in a greenhouse at Columbus.

Control measures were rather widely used during 1946 and the effects of such measures were reflected in the conditions in outdoor tomatoes. Several fields that were damaged in 1945 were free from injury in 1946. On the other hand, an occasional field near the edge of the infested area was damaged, where no injury had been observed during the previous year. Inasmuch as the entire Cleveland area in which hothouse tomatoes are grown was infested during 1945, no increase in the infested area was observed in 1946.

During the winter of 1947-1948 an infestation appeared in Ashtabula County. Thereafter, no new infestations were observed and the damage occurring in both hothouse and outdoor tomatoes gradually decreased. Apparently the insect had been eliminated from a number of greenhouses by the careful application of effective control measures.

NATURE OF INJURY

Although the tomato pinworm is primarily a pest of tomatoes, it feeds extensively on potato and eggplant foliage when such plants are

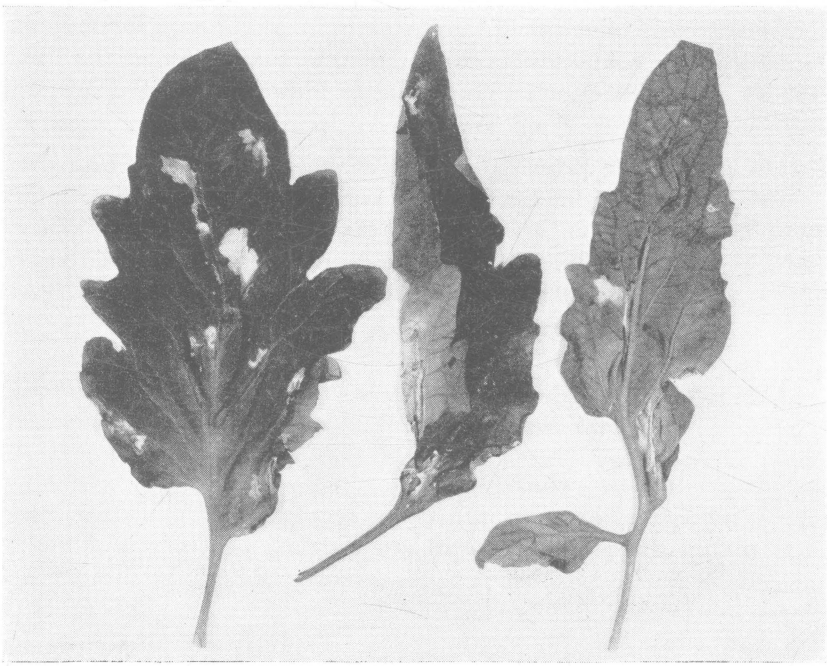

Figure 1.—Tomato Leaflets Showing the Mines of Tomato Pinworm Larvae.

growing near infested greenhouses. It has also been reported (3) on horse nettle. Fortunately it is not known to attack any common hothouse plant except tomato.

On young tomato plants the most common type of pinworm injury is caused by the larvae mining between the leaf surfaces. A larva may feed as a leaf miner until it is half grown (Fig. 1), then leave the mine and roll together a small part of a leaf and feed inside the enclosure. Sometimes the leaves are either destroyed or so badly damaged that they are of no further use to the plant (Fig. 2). Sometimes the stems are invaded (Fig. 3). In 1944, before control measures were available, a number of potted plants were killed in commercial greenhouses, and many others were rendered worthless.

On large plants growing in the main range of a greenhouse, the foliage injury consists chiefly of leaf mines and folded leaflets in the lower leaves (Fig. 1). In severe infestations all leaves are attacked and the plants may not set fruit, or the fruit may be stunted or deformed. However, the greatest economic damage results from fruit injury (Figure 4). Larvae may bore into the side of a tomato, but more often they crawl under the sepals at the stem end and burrow into the fruit at that point. They leave tiny pinholes at the points of entry and such entrances may not be observed or recognized readily. Consequently, the insect may be carried from one area to another by marketing wormy tomatoes. It seems probable that it may have entered Ohio in that manner.

LIFE HISTORY

The adult moths resemble clothes moths in size and color. They are quite active at dusk, but do less flying during the day. When the plants and mulch are disturbed in daytime, however, moths may fly erratically for short distances and then settle down and again become inconspicuous.

The eggs are usually deposited on the lower surface of tomato leaves, but may be placed on the stems, sepals, or even on the fruit. The egg is oval in shape and is so small that it is not seen readily with the unaided eye.

The general color of the newly hatched larva is light orange, but it gradually darkens to a purplish-black as the larva approaches maturity. The color markings are distinctive in that the pattern on each segment roughly resembles a pair of spectacles. A full-grown larva measures approximately one-fourth inch in length. It usually drops to the ground on a silken thread and changes to a pupa in a cell just under the surface of the soil. However, pupation may occur within folded leaves or even in tomatoes. Within a few hours after the moths emerge, they return to the surface and soon begin laying eggs.

In a study of the life history of the tomato pinworm (5), the insect was carried through three generations in a greenhouse at the Experiment Station. Rearing cages consisted of lantern globes, 11 inches high and 5½ inches in diameter at the top, covered with cheesecloth held in place with rubber bands. These were used on benches in the greenhouse and a tomato plant approximately 6 inches high growing in a 3-inch pot was introduced as the rearing medium. Approximately 25

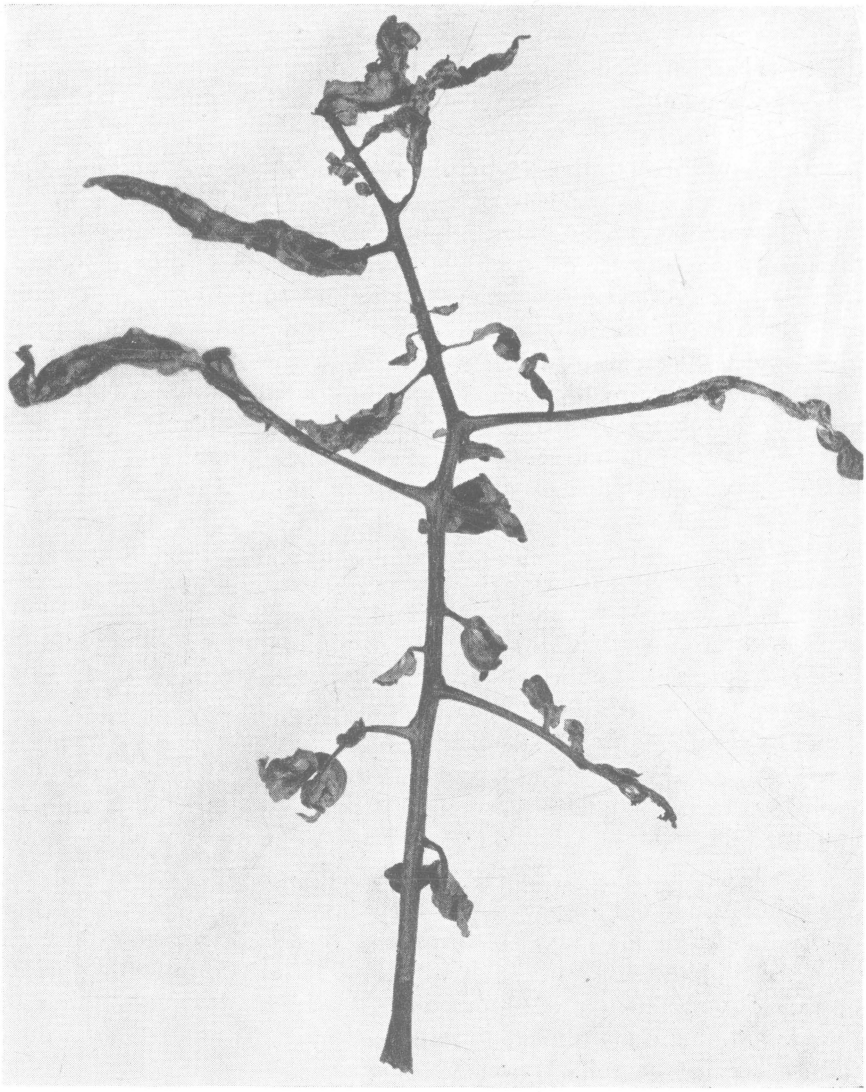

Figure 2.—A Tomato Leaf Severely Injured by the Tomato Pinworm.

pinworm moths were maintained in such a cage and a new plant was introduced each day in order that all eggs deposited on a plant were laid within a 24-hour period.

Infested plants obtained in this manner were held in cages until all larvae had completed their development and emerged as moths. Moth emergence was recorded each day. During the winter of 1945-1946 a total of 138 moths were reared from 9 infested plants. The data obtained are summarized in Table 1. The average temperature in the greenhouse during the period in which the study was made, determined from the average of the maximum and minimum for each day, was approximately 70 degrees F. As shown in Table 1, the length of the life cycle extending from egg deposition to moth emergence varied from 46 to 68 days and averaged 54.6 days.

The temperature inside the greenhouse was then raised approximately 5 degrees and 38 insects were carried through a second generation at the higher temperature. For this group the length of the life cycle varied from 30 to 45 days and averaged 37.6 days. Thus a rise in average temperatures of approximately 5 degrees resulted in shortening the life cycle 17 days.

The length of the incubation period was determined for 17 individual eggs at the higher temperature. This period varied from 9 to 12 days and averaged 10.6 days. The combined feeding and pupal period, therefore, was 27 days.

Life history studies were again repeated in the same manner during the summer months of 1947 (7). The average temperature was not determined during this period, but the work was done from July 3 to September 20 which was the warmest part of the summer. The incubation period at that time was determined for 51 eggs. It varied from 5 to 8 days and averaged 6.4 days. None of the eggs under observation failed to hatch.

The length of the life cycle, extending from egg deposition to moth emergence, was determined for 190 individuals as shown in Table 2. The period varied from 22 to 42 days. Thirty-four individuals required 31 days in which to complete the cycle, but the average for the 190 individuals was 29.5 days. The combined larval and pupal period, therefore, was 23 days.

The variation in the length of the life cycle of the tomato pinworm at different temperatures seems unusually great. Although the temperature in the greenhouse during November and December 1945 was not unusually low, the length of time required for the insect to complete its development at that time was nearly double that required during the summer of 1947.

Table 1.—Length of Pinworm Life Cycle — November - December, 1945

No. days egg to adult	Number of insects reared from egg to adult, with dates of egg deposition shown									Total
	11/14	11/16	11/18	11/21	11/23	11/25	11/26	11/29	11/30	
46								1		1
47							1		1	2
48					1			1	6	8
49			1		3			1	5	10
50				1	6	1		1	2	11
51		4		2	4				4	14
52		2		3	2		1	1	3	12
53	1		1	4				1	1	8
54		1	2	2	8				2	15
55		1	2		6					9
56		1		3	1					5
57			1	2	3					6
58		1		1	3					5
59					7					7
60	3		1	1						5
61	2									2
63	7		1							8
64	5									5
65	2									2
67	2									2
68	1									1
Total insects	23	10	9	19	44	1	2	6	24	138
Ave. – days	63.0	53.1	55.5	54.1	54.1	50.0	49.5	49.7	50.0	54.6

Table 2.—Length of Pinworm Life Cycle — July to September, 1947

No. days egg to adult	Number of insects reared from egg to adult, with dates of egg deposition shown											Total
	7/3	7/4	7/5	7/6	7/18	7/19	7/20	8/12	8/13	8/16	8/17	
22									1			1
23						3			2			5
24					1	2		4	3			10
25					2	2	3		2			9
26					2				2		9	13
27					8	2			1		1	12
28					1	5	8		2			16
29					9	6		4				19
30			6		10	4			8	1		29
31			1	1	10	2		17		3		34
32	1		2	1	1	1		2				8
33	1	1		1	1				14			18
34	2								3		1	6
35				2					4			6
36				1								1
37				1				1				2
42				1								1
Total insects	4	1	9	8	45	27	11	28	42	4	11	190
Ave. – days	33.3	33.0	30.6	35.1	29.0	27.7	27.2	30.0	30.2	30.8	26.8	29.5

WINTER MORTALITY

During the winter of 1945-1946, a study was made of the possibility that the pinworm might survive out-of-doors in Ohio. Infested tomato

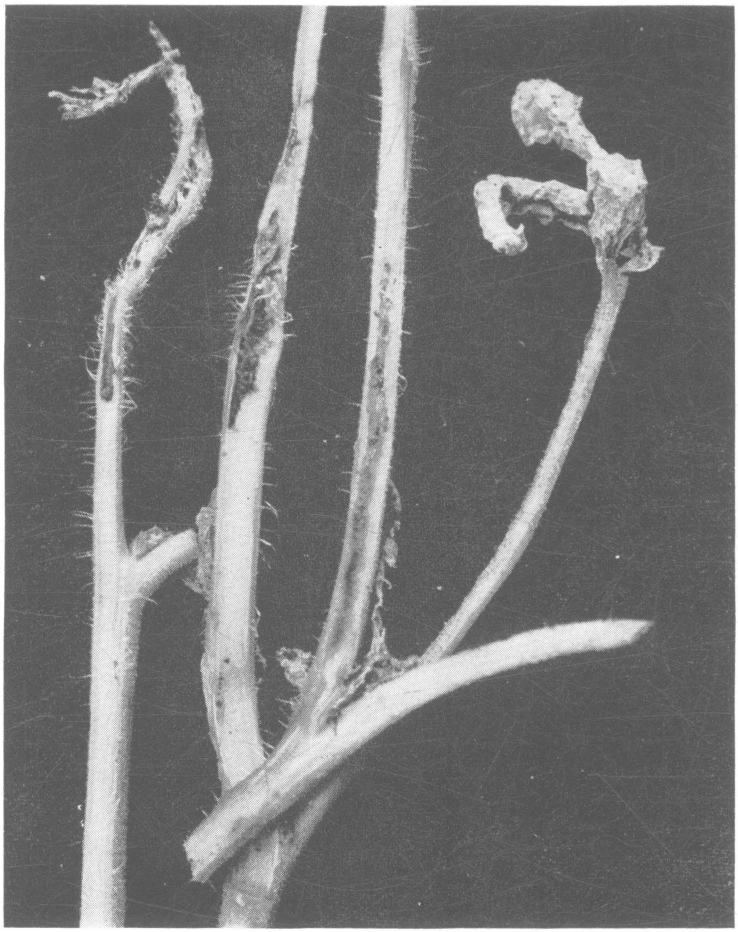

Figure 3.—Stems of Tomato Seedlings Injured by the Tomato Pinworm.

plants and fruits were collected from heavily infested fields during the latter part of October and placed in cages. Five cages were employed and approximately 1500 larvae were included. Two of the cages were placed in an out-door insectary at Wooster; two were placed in a tomato field at Berea, one over a straw mulch and the other over bare ground; and the fifth cage was placed over a heavy growth of grass and weeds at Elyria.

The five cages were examined at frequent intervals during the spring and were dismantled early in the summer of 1946. No living moths or larvae could be found in any cage. In view of the fact that the winter of 1945-1946 was unusually warm, this record indicates that the pinworm is not likely to survive a normal winter out-of-doors in the latitude of northern Ohio.

The distribution of the pinworm in Ohio also indicates rather definitely that the insect has lived over winter only on hothouse tomatoes. Severely damaged tomato fields have been observed, but such fields were always located near infested greenhouses. Also, such injury did not reappear in succeeding years when the insect was well controlled in the neighboring greenhouse.

CONTROL EXPERIMENTS

In August, 1944 (5), soon after the pinworm infestation was found in Ohio, a series of control experiments were undertaken in a commercial greenhouse. The tomato plants in the area selected for the experiments were approximately 2 feet in height and were being damaged by pinworm larvae.

Six sprays were tested in one series and six dusts in another. Each treatment as well as an untreated check in each series was replicated three times. Plots consisted of 4 rows with 20 plants to the row. Each treatment, therefore, was applied on 240 plants. Sprays were applied with a Myers Silver Prince power sprayer and the dusts with a rotary type hand duster. The applications were made on August 16-17 and again one week later.

Infestation counts were made one week after the second application by counting all living larvae that could be found on 10 consecutive plants near the center of each plot. All leaf mines and folded leaflets were opened in order to observe the larvae within. The data obtained are summarized in Table 3.

As indicated in Table 3, 70 percent cryolite was the most effective dust used. The spray that contained cryolite also proved effective.

A third application of experimental treatments was made on September 6 and 7, but the two dusts and the two sprays that appeared least effective in the first two applications were not used in the third application. Rotenone and DDT, both used as dusts and sprays, were substituted. The check plots which were becoming heavily infested were also treated with DDT.

One week after the materials were applied infestation counts were made by counting the living larvae found on five consecutive plants in each plot. The plants at that time were approximately 3 feet high. The data are summarized in Table 4.

Table 3.—Pinworm Larvae Found in 10 Tomato Plants.
August 29 to 31, 1944.

Materials	Larvae in 10 plants			Mean
	Rep. 1	Rep. 2	Rep. 3	
Dusts				
Cryolite, 7 parts; Talc. 3 parts	5	7	4	5.3
Cryolite, 1 part; Talc, 2 parts; Flour, 2 parts	4	15	40	19.7
Lethane Dust (B-71) 2%	14	31	18	21.0
Dutox, 1 part; Talc, 2 parts; Flour, 2 parts	14	57	6	25.7
Lead arsenate, 1 part; Talc, 5 parts; Flour, 2 parts	14	50	15	26.3
Calcium arsenate, 1 part; Lime, 1 part; Talc, 4 parts; Flour, 2 parts	14	42	25	27.0
Check (No treatment)	59	44	16	39.7
Sprays (Materials in 100 gallons)				
NNOR, 1 quart	0	3	2	1.7
Cryolite, 5 pounds; DuPont Spreader-Sticker, 3 ounces	4	4	6	4.7
Dutox, 5 pounds; DuPont Spreader-Sticker, 3 ounces	9	10	5	8.0
Lead arsenate, 4 pounds; DuPont Spreader-Sticker, 3 ounces	15	8	9	10.7
Lethane B-72, 2½ pounds	26	22	59	35.7
Calcium arsenate, 4 pounds; Lime, 4 pounds; DuPont Spreader-Sticker, 3 ounces	16	36	60	37.3
Check (No treatment)	118	28	69	71.7

Cryolite again proved effective both as a dust and as a spray. The cryolite, as well as the 70 percent dust, reduced the pinworm population to approximately one larva per plant. DDT, however, proved much more effective. No larvae were found on 30 plants that were sprayed with DDT, and only 3 larvae were found on 30 plants that received the 5 percent DDT dust. This occurred in spite of the fact that half of the plots treated with DDT originally constituted the check plots and were heavily infested when the treatments were applied.

While this work was under way, two tests were made of the efficiency of tobacco fumigation in killing adult moths. A measure of the effectiveness of such a treatment was obtained by counting the living moths that could be found before and after fumigating. In each case a search for moths was made during a half-hour period in the tomato rows near the outer walls of the greenhouse where the moths were most abundant.

In the first test a commercial brand of tobacco powder was used at the rate of 1 pound to 52,000 cubic feet. The powder was burned at 8 p.m. and the greenhouse remained closed throughout the night. A total of 78 moths were found during a half-hour period before fumigating and only two were seen the next day, indicating that 97 percent were killed.

Table 4.—Pinworm Larvae Found in Five Tomato Plants.
September 14 and 15, 1944.

Materials	Larvae in 5 plants			Mean
	Rep. 1	Rep. 2	Rep. 3	
Dusts				
DDT, 5%*	0	0	1	0.3
DDT, 5%**	0	1	1	0.7
Cryolite, 7 parts; Talc, 3 parts	6	3	5	4.7
Cryolite, 1 part; Talc, 2 parts; Flour, 2 parts	2	2	22	8.7
Dutox, 1 part; Talc, 2 parts; Flour, 2 parts	9	15	8	10.7
Lead arsenate, 1 part; Talc, 4 parts; Flour, 3 parts	6	39	19	21.3
Cube Root (5% rotenone), 1 part; Talc, 6 parts***	12	19	36	22.3
Sprays (Materials in 100 gallons)				
DDT, 1 pound (4 lbs. of 25%)*	0	0	0	0
DDT, 1 pound (4 lbs. of 25%)**	0	0	0	0
Cryolite, 5 pounds; DuPont Spreader-Sticker, 3 ounces	2	5	8	5.0
Lead arsenate, 4 pounds; DuPont Spreader-Sticker, 3 ounces	12	25	11	16.0
NNOR, 1 quart	13	22	24	16.3
Dutox, 5 pounds; DuPont Spreader-Sticker, 3 ounces	8	33	24	21.7
Cube Root (5% rotenone), 4 pounds***	17	50	39	35.3

* These constituted the check plots for the first two applications.
** Plots that received Lethane in the first two applications.
*** Plots that received calcium arsenate in the first two applications.

In a similar experiment, Nico-Fume in pressure fumigators was used at the rate of approximately 1 pound to 50,000 cubic feet. In counts of adult moths, 280 were found in a half hour before fumigating and 53 the next day, indicating that 81 percent had been killed.

As the results of experimental work became available during the fall of 1944, the commercial hothouse tomato growers in the infested area began dusting with cryolite. Also nicotine fumigation was prac-

ticed when the adult moths were observed in considerable numbers. As a result of these practices no appreciable commercial damage resulted.

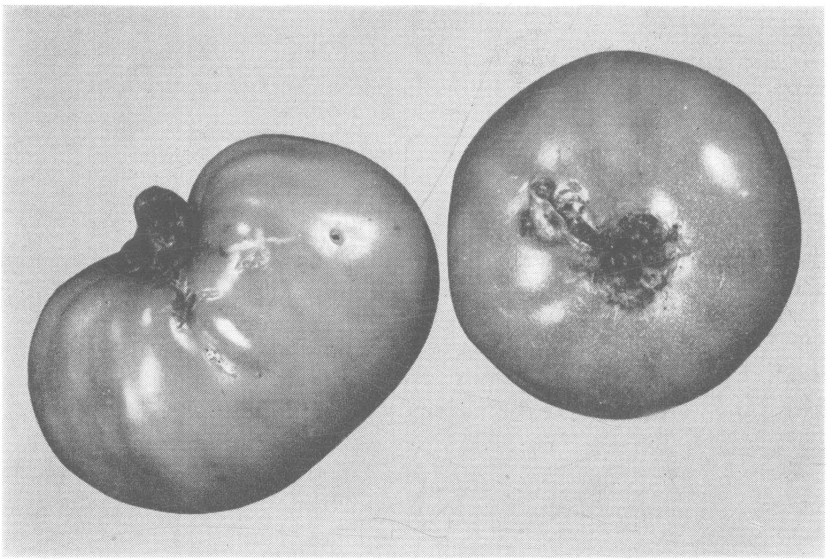

Figure 4.—Tomato Fruits Injured by Tomato Pinworm Larvae.

During the latter part of October all of the tomato plants in a greenhouse of slightly more than one-half acre were sprayed with DDT at the rate of 1 pound in 100 gallons (4 pounds of a 25 percent wettable powder). The plants were large and the growing tips had been removed several days before the spray was applied. Consequently, little new foliage developed that was not covered with the insecticide. Ten plants selected at random were examined for pinworm larvae before spraying. On these, 111 larvae were taken. On October 25, 4 days after the spraying was completed, 15 plants were carefully examined and only 3 larvae were found. On November 10, on another series of 15 plants, not a single larva could be found.

Moths could be observed in the house until the middle of November. On November 10, 35 were counted during a 15-minute search. Apparently they were entering from the outside because larvae could be found on every leaflet in a small tomato planting nearby, and many moths were observed in weeds growing adjacent to the greenhouse walls. Later examinations were made inside the greenhouse, but no living larvae were found after October 25, and by the end of November the moths had also disappeared.

During 1945 a number of growers used a 5 percent DDT dust and obtained excellent control, but foliage injury sometimes occurred. Consequently experiments with more dilute dusts were carried on during 1946 and 1947. A 3 percent dust proved effective and in 1947 a rather heavy population was practically eliminated wtih two applications of a 2 percent dust. It was applied at the rate of approximately 29 pounds per acre with an interval of 17 days.

In 1948 the aerosol grade or purified DDT became available. It proved less toxic to tomato foliage than the technical form although it was just as effective in control of the tomato pinworm.

Since that time a 3 percent aerosol grade DDT dust at the rate of approximately 25 pounds per acre has been used extensively in Ohio greenhouses for the control of the tomato pinworm as well as for a number of other tomato and cucumber insect pests. It is applied with a small power duster mounted on a wheelbarrow. With the greenhouse ventilators closed, the dust is blown into the air above the plants. By wheeling the duster between the middle rows of each unit of a greenhouse a dense fog is created throughout the greenhouse. As the dust settles a light deposit forms on each plant.

A limited survey of the status of the insect made during September 1949 showed that this method has been unusually successful in control of the tomato pinworm. None of the insects were found west of Elyria or east of Cleveland. Although a few individuals were observed in various places west of Cleveland, in no locality were they found sufficiently abundant to be observed readily. The pinworm population has been greatly reduced throughout Ohio and apparently has been eliminated from Franklin and Ashtabula Counties and from a number of other communities.

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